Space Technology Research Grants

Close Proximity Robotic Maneuvering through Flux Pinning Manipulation

Completed Technology Project (2015 - 2019)

Project Introduction

Non-contacting actuation technology like flux pinning has never been demonstrated in space. The development of a nonphysical joint is critical for maneuvers such as docking, rendezvous, and in-orbit assembly (NASA Technology Area 4: robotics, tele-robotics and autonomous systems). Flux pinning is not well characterized for interactions that involve all six rigid-body degree of freedoms. My research will focus on developing a better mathematical model and constructing a spaceflight system to demonstrate prolonged flux pinning interactions. I will develop this model to show that flux pinning is robust enough to overcome environmental torques and magnetic field disturbances, given well simulated, tested, and robust control algorithms and system architectures (TRL, Technology Readiness Level 4). I will then construct a test environment to iteratively validate the theoretical model and demonstrate dynamic manipulation (TRL 5-6). To prove that this will be feasible in space missions, I will develop fully integrated CubeSats to perform maneuvers on these testbeds (TRL 7). A successful space flight demonstration of flux pinned system will give way to a completely new kind of space proven joint. Spacecraft would no longer need to be assembled on the ground in bulky, awkward shapes. Systems of flux pinned components could be easily replaced with another or autonomously repaired in orbit with minimal effect on the entire system. The Hubble telescope was launched out of focus, requiring millions of dollars to train astronauts and launch a crew to refocus the mirrors. This is a distinct example of the advantages to in-orbit assembly/adjustment. Instead of risky spacewalks with skilled astronauts, the skewed mirrors of the telescope could have been adjusted and finely tuned by commanding the modular pieces from the ground. Telescopes require cold environments (80 K) which pairs well with flux pinning requirements. Flux pinned satellites could also function like the research racks on the ISS, but mounting to the outside environment. Small contained experiments could easily be swapped out, without the involved installation and take-down period requiring risky spacewalks and valuable astronaut time.

Anticipated Benefits

A successful space flight demonstration of flux pinned system will give way to a completely new kind of space proven joint. Spacecraft would no longer need to be assembled on the ground in bulky, awkward shapes. Systems of flux pinned components could be easily replaced with another or autonomously repaired in orbit with minimal effect on the entire system. The Hubble telescope was launched out of focus, requiring millions of dollars to train astronauts and launch a crew to refocus the mirrors. This is a distinct example of the advantages to in-orbit assembly/adjustment. Instead of risky spacewalks with skilled astronauts, the skewed mirrors of the telescope could have been adjusted and finely tuned by commanding the modular pieces from the ground. Telescopes require cold environments (80 K) which pairs well with flux pinning requirements. Flux pinned satellites could also function like the

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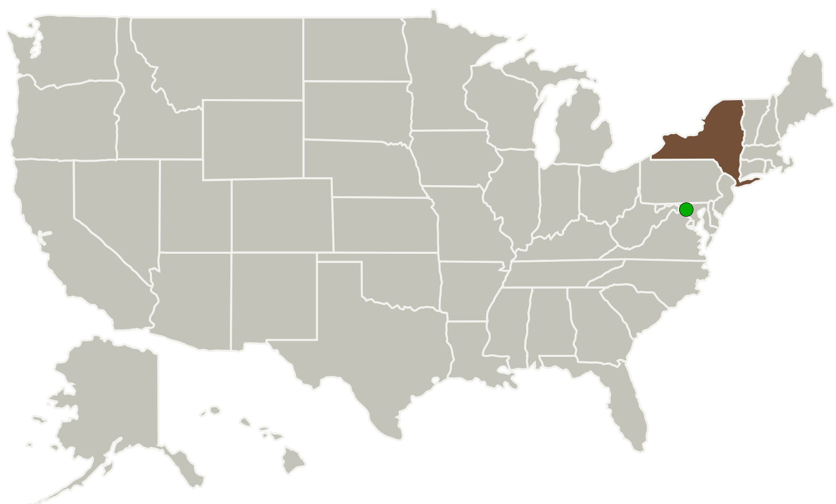
Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
Cornell University	Lead Organization	Academia	Ithaca, New York
Goddard Space Flight Center(GSFC)	Supporting Organization	NASA Center	Greenbelt, Maryland

Primary U.S. Work Locations
New York

Project Website:

https://www.nasa.gov/strg#.VQb6T0jJzyE

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

Cornell University

Responsible Program:

Space Technology Research Grants

Project Management

Program Director:

Claudia M Meyer

Program Manager:

Hung D Nguyen

Principal Investigator:

Mason A Peck

Co-Investigator:

Frances Zhu

Technology Maturity (TRL)

Start: **2**
Current: **3**
Estimated End: **3**

Applied Research			Development			Demo & Test		
1	2	3	4	5	6	7	8	9

Technology Areas

Primary:

- TX04 Robotic Systems
  └ TX04.5 Autonomous Rendezvous and Docking
    └ TX04.5.5 Capture Mechanisms and Fixtures

Target Destinations

Earth, The Moon